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Electrical Equipment Parameter Acquisition System Based on Wireless Ethernet

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The basis for designing a system for the remote collection of electrical equipment parameters is a miniature high-performance controller and wireless Ethernet technology. At the center of the data collection section is a microprocessor; that can be used in two ways: as a monitor alone, or it can be installed. Using the example of a welding machine, the main functions of the microprocessor are the collection of electrical equipment parameters, processing calculations, displaying parameters, and communication with the PC at the main control center site. Via Yuanline Ethernet, the client/server mode is used to realize remote communication, and VC++6 is used to develop the related software; this realizes the remote monitoring, measurement and acquisition of the parameters of electrical equipment. Under the Linux STM32 single-chip microcomputer platform, through the layered serial protocol, the serial interface settings of the lower computer iMX and the upper STM32 are realized respectively, so that the upper and lower positions are not synchronized. The basic conditions of the line communication are guaranteed, the specific data packet format and the middle-level transmission protocol are set, and the exact and definite transmission of the aggregate data, composed of a large amount of data, is realized through the STM32 real-time collection of data on the CAN line. Packing these contents in a specific format can reduce the amount of forwarded data, greatly improve the scalability and performance of the device, and creates a specific reference value for the conversion between two communication devices under specific data.

Keywords: Electrical equipment; Wireless Ethernet; STM32; Parameter collection

1. INTRODUCTION

Network infrastructure has been gradually improved and developed in recent years. In order to achieve wireless Ethernet coverage, a large number of hot spots have been created in urban infrastructure. Based on wireless Ethernet technology, the cost of networking has been greatly reduced [1]. Compared with other technologies, 2.4G wireless transmission has many advantages, such as long transmission distance and fast transmission speed. At present, most companies manage electrical equipment mainly at the workshop control level, and some information can only be obtained at the work site, including electrical equipment related parameters and alarm status. This presents several challenges: it reduces the reliability and real-time performance of management, and also greatly reduces the production and development efficiency of enterprises [2]. The rapid development of embedded technology has brought many benefits: more convenient and efficient data transmission, more reliable single-chip performance, and a simpler interface Embedded technology has become more cost-effective, and it provides excellent ways to control equipment, and collect and transmit data. The operation of the single-chip microcomputer is needed to complete the collection of network information. As the application of embedded information collection technology in the industrial field has become increasingly extensive, the research and optimization of single-chip microcomputers has become the key investment project of many industrialized enterprises [3–5]. The application of wireless transmission technology has provided great help for the information collection and information transmission of industrialized enterprises [6]. The use of wireless

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transmission technology for information transmission can not only reduce the capital investment of enterprises, but can also use traditional information transmission technology, giving higher overall returns [7]. Additionally, the operating status of the transmission production system and equipment can be safely monitored.

2. ANALYSIS OF THE THEORETICAL BASIS OF WIRELESS ETHERNET

2.1 Introduction and Comparison of Several Short Distance Wireless Communication Technologies

2.1.1 IrDA Technology

IrDA technology is a kind of communication technology where the maximum transmission distance is 4m, with relatively perfect software facilities and hardware technology. Compared with traditional information transmission technology, the media used by IrDA technology has many advantages. Traditional information transmission technology needs copper wire and optical cable in information transmission, while IrDA technology only needs infrared rays to complete information transmission [8]. Therefore, this technology consumes less energy, requires less material, and has higher security than traditional information transmission technology [9]. According to the latest specification, the transmission limit rate of IrDA is 4Mbps. However, this specification is obtained with a short distance information transmission test, so when there is a longer information transmission distance, the speed is reduced and the specification is no longer applicable. One of the other serious defects of IrDA technology is its poor penetration ability of obstacles, and over longer distances, the environment in the transmission process will be more complex, so the short distance specification is not applicable in long-distance transmission [10].

2.1.2 Bluetooth Technology

Bluetooth technology is widely used in our daily lives. Most people use Bluetooth to synchronize data over short distances. Bluetooth technology can not only perform short-distance data synchronization functions, but also has 2.4G wireless technology with multiple device connection functions. Its advantages are: low power consumption, good communication security, and it can be used to detect and connect to a wide range of devices. Today's Bluetooth technology uses a very advanced hardware manufacturing process, where most companies use semiconductors as materials when manufacturing Bluetooth hardware [11]. The power consumed by a general Bluetooth device during data synchronization is closely related to the amount of synchronized data and the distance between the synchronization and the synchronized device. As the amount of data and distance between devices increases so too does the power consumption. When the amount of data that needs to be synchronized is too large and the distance between the devices is too far, the Bluetooth device will have functional obstacles or even fail to achieve data synchronization [12]. As the use of Bluetooth technology for data synchronization has a high cost and low synchronization rate, the application range of Bluetooth technology in wireless monitoring networks is relatively low [13].

2.1.3 ZigBee Technology

ZigBee technology, like Bluetooth and WIFI, is a communication technology that works at 2.4GHz. It is a communication technology based on the IEEE 802.15.4 standard that is mainly suitable for automatic and remote control. The frequency can be set to 868MHz 915MHz or 2.4GHz. At 2.4GHz, the transmission rate is 250kbit/s, and the data transmission distance is 10 to 70 meters. Therefore, ZigBee technology will be widely used in fields such as smart homes, road traffic management, and traffic information statistics. The advantages of this technology are that it requires fewer funds, does not cause patent disputes with other companies, has the ability to self-organize, has good reliability, and has a large network capacity. The disadvantages are that the efficiency of information transmission is low, the distance of information transmission is short, and the range that the network equipment signal can cover is small. In order to overcome these shortcomings, workers in related fields will deploy a large number of Bluetooth devices in a certain area to increase the coverage area and transmission distance of Bluetooth devices. At the same time, the staff also established a more complex data synchronization network. The Bluetooth devices in China have previously been able to perform information synchronization and information transfer, which will undoubtedly improve the efficiency of information transfer and information synchronization to a large extent.

2.1.4 Wi-Fi Technology

As a typical short-distance wireless transmission technology, Wi-Fi is also widely used in human life. The most significant advantage of this technology is that it can support a variety of efficient information transmission, so Wi-Fi technology can transmit information at a corresponding speed in different working environments. The disadvantage is that the rate of information transfer is more severely affected by the transfer distance. As the transfer distance increases, the rate of information transfer decreases dramatically. In reallife situations, the most widely used field of Wi-Fi technology is the field of wireless local area network.

The comparison of several common short-range wireless communication technologies in this field is shown in Table 1:

It can be seen from Table 1 that compared with several other technologies, Wi-Fi not only has the advantages of wide coverage, information synchronization and higher information transmission rate, but also has the advantages of lower transmission cost, relatively stable transmission rate, and the structure of information transmission network.

2.2 Industrial Wireless Ethernet Communication Network

It is very difficult to lay cables at a sintering production site, as the environment is harsh and the measuring point is generally

Table 1 Comparison of several short-range wireless communication technologies.

Communication technology	Communication rate	Single point coverage distance	System power consumption	Remote communication support
IrDA	4Mbps	2m	Lower	Not support
Bluetooth	1 Mbps	10–100m	Higher	Not support
Zigbee	<1 Mbps	50m	Low	support
Wi-Fi	54Mbps	>100m	High	support

Table 2 Wireless network related configuration.

Make up	Ethernet module	Subnet mask	IP address
S7-200 PLC	CP243-1	255.255.0.0	192.168.0.1
S7-300 PLC	CP343-1	255.255.0.0	192.168.0.2
Access Point A	EKI-6311GN	255.255.0.0	192.168.0.3
Access Point H	EKI-6311GN	255.255.0.0	192.168.0.4

too far away from the sintering monitoring room. Therefore, for data transmission an industrial-grade product network with strong anti-interference and high reliability must be chosen. By combining the wireless data transfer network and industrial Ethernet, the information transfer between various devices in the industrial wireless Ethernet network can be realized. Wireless transmission technology is not only recognized by scholars in the field of computer science and the Internet, but also by many industrial companies. After years of research, related workers have discovered that the wired control network and the wireless local area network are best used in conjunction, especially when the nodes of the wired control network are used to realize the information conversion of the wireless local area network. In addition, by using the wide equipment coverage area of the wired control network, the distance and range of wireless LAN information transmission can be increased, which can effectively alleviate the shortcomings of short wireless LAN information transmission distance and smaller information coverage.

There are various types of nodes in the industrial wireless Ethernet communication network. After each different node receives data, it uses the Ethernet packet to filter and sort the data, and the sorted data is then transported to the specified network through a specific network line. All data will be converted into a format that can be recognized by Ethernet at the access point. The detailed information of the IP settings and related hardware devices in a wireless local area network can be seen in the following table. Due to the possibility of security breaches and in order to prevent the loss of core technology and trade secrets it is essential to strengthen the security of the network. To test the security performance of the existing network the position of the input node and the position of the output node in the industrial wireless Ethernet can be adjusted

3. DESIGN AND REALIZATION OF ELECTRICAL EQUIPMENT PARAMETER COLLECTION SYSTEM

3.1 Overall System and Hardware Design

This paper studies domestic and foreign electrical equipment parameter network monitoring methods, and intends to use the hardware facilities of the electrical equipment collection module in the design. Based on a more powerful processor, this paper uses a 32ARM processor to achieve electrical equipment work display, collection, processing and transmission of processed data and related status.

3.2 System Circuit Design

The simulation analysis of the explosion-proof performance data is mainly carried out through Multisim software. The simulation is the circuit in the hardware design of the robot data acquisition system, in order to verify whether the principle of compounding: that is, whether the voltage and current of each component meet safety circuit design. At the same time, it can be verified if the designed circuit is explosion-proof. The evaluation rules of intrinsically safe circuits are the main basis for this section of simulation experiment analysis. When planning to explain simple capacitive circuits and inductive circuits, clear examples need to be cited in order to verify the accuracy and rationality of the circuit design. Theoretical analysis and simulation analysis are also necessary. The “IA” level is the explosion-proof requirement of safety for simple inductance circuits, so based on the above, an IIC circuit shown in Figure 2 assumes that a 100mH, 1100Ω inductance is powered by a 300Ω current limiting resistor and a 20V battery pack.

As shown in Figure 3 below, the simulation analysis of this circuit is similar to the power supply evaluation.

For a simple capacitor circuit, the simulation is basically similar to the inductance circuit. As shown in Figure 4, a 10μF capacitor, a reliable resistance of 10kΩ and a 30V battery pack form the power supply. In this circuit, 30V and 10μF are the maximum values, and 10kΩ is the minimum.

3.3 Data Acquisition Module Design

This AI/DI data acquisition has a real-time control system. Due to the high processing speed of data acquisition, the number of sampling points should be appropriate, this can effectively shorten the data acquisition cycle. Before the collected data reaches the set requirements, DAQmx the

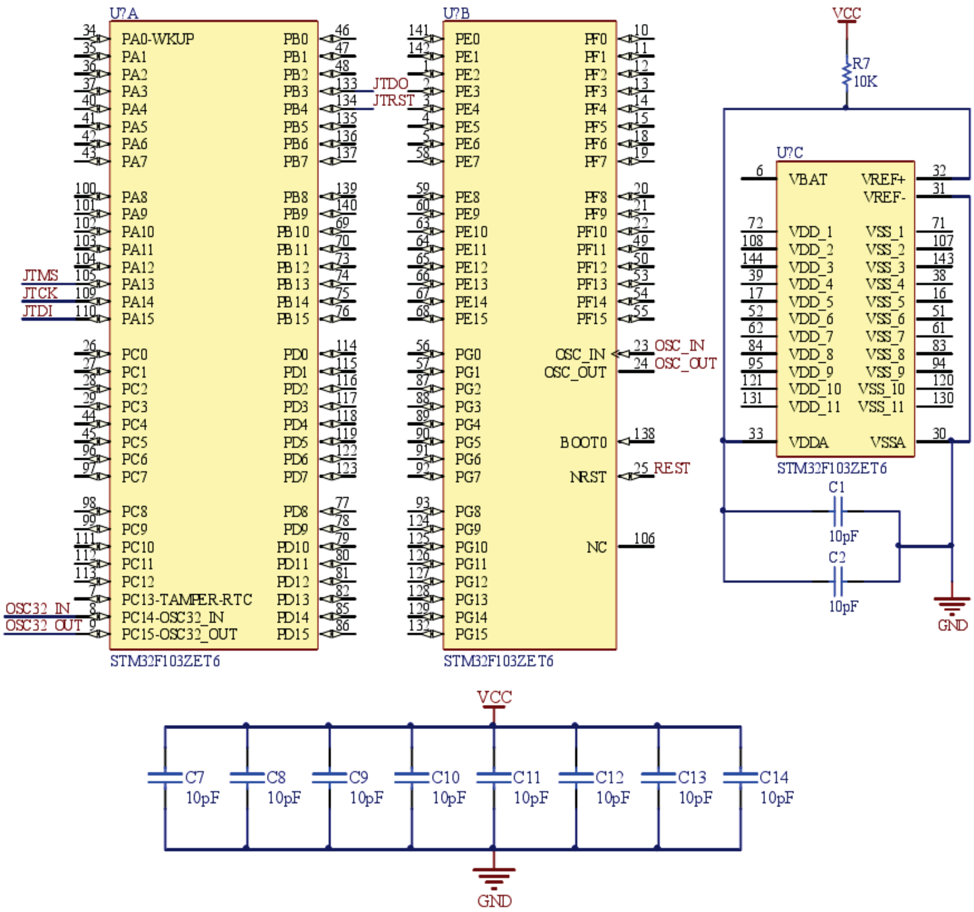

Figure 1 Main control chip circuit.

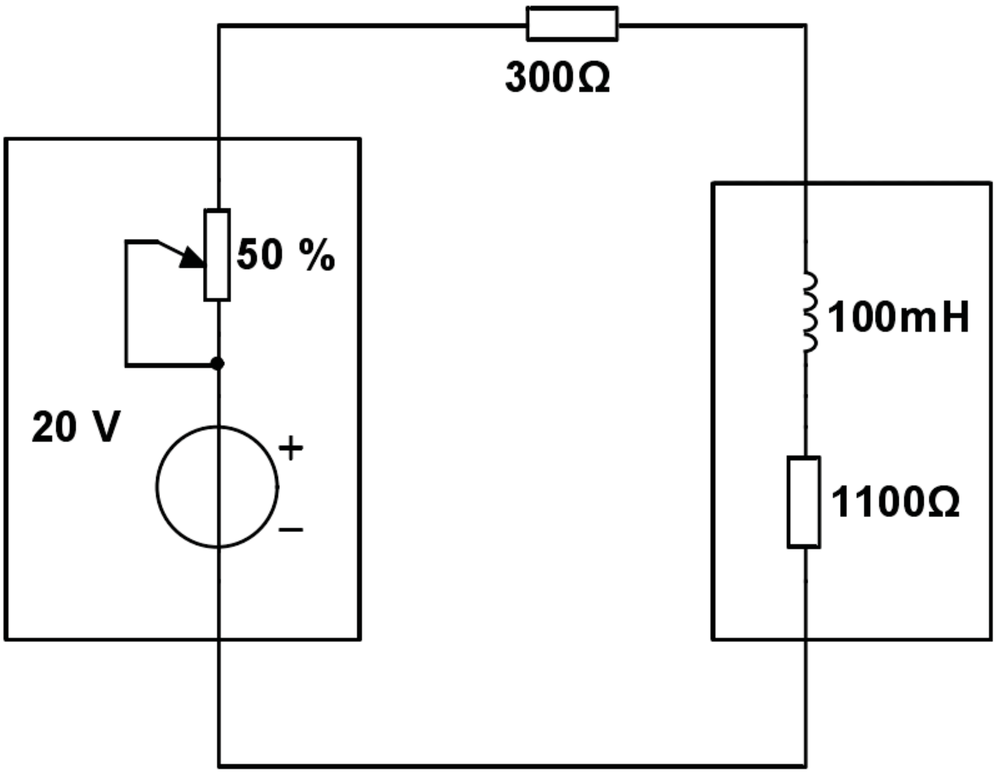

Figure 2 Simple inductance circuit.

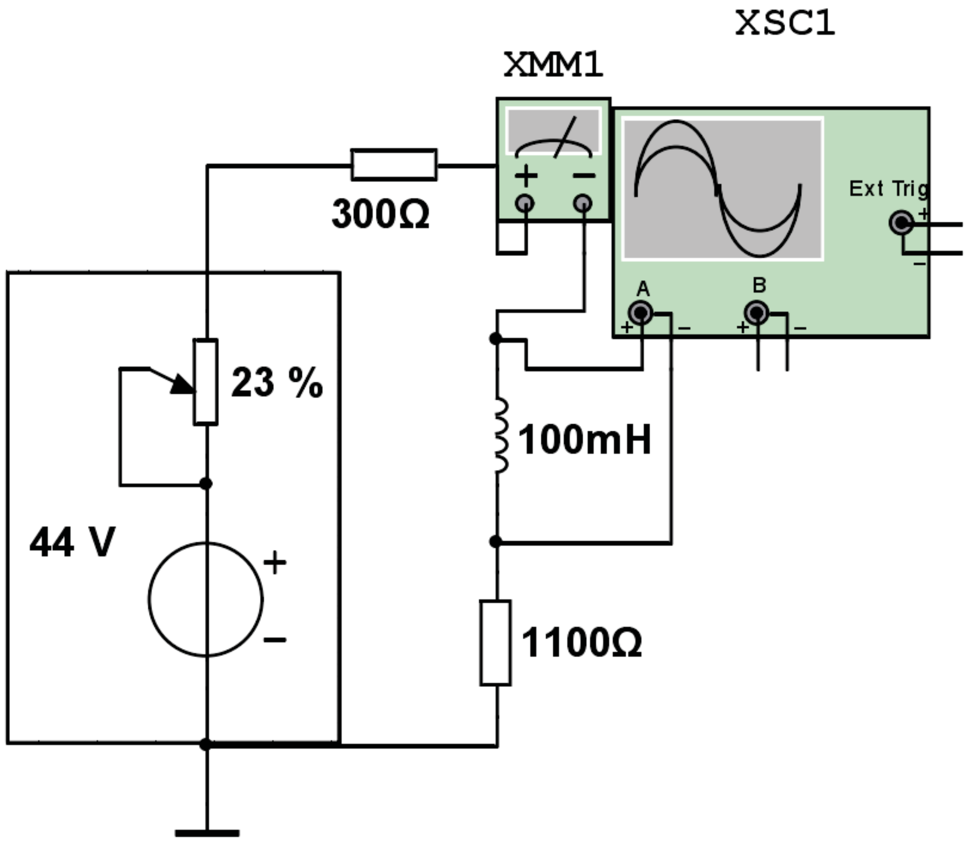

Figure 3 Inductance circuit.

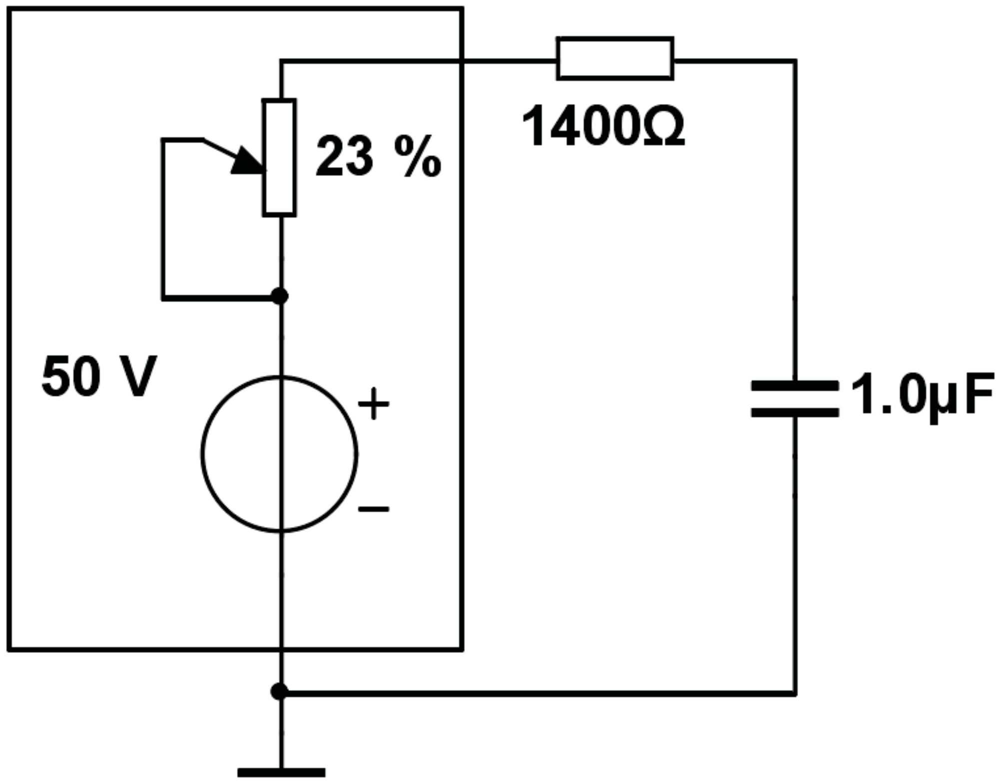

Figure 4 Capacitor circuit.

"AIRead" read function adopts a polling method to query data, so that the polling time between two "AIRead" functions can be obtained. Some people will intentionally insert a "Wait" command to release the CPU time occupied by polling as this improves CPU utilization.

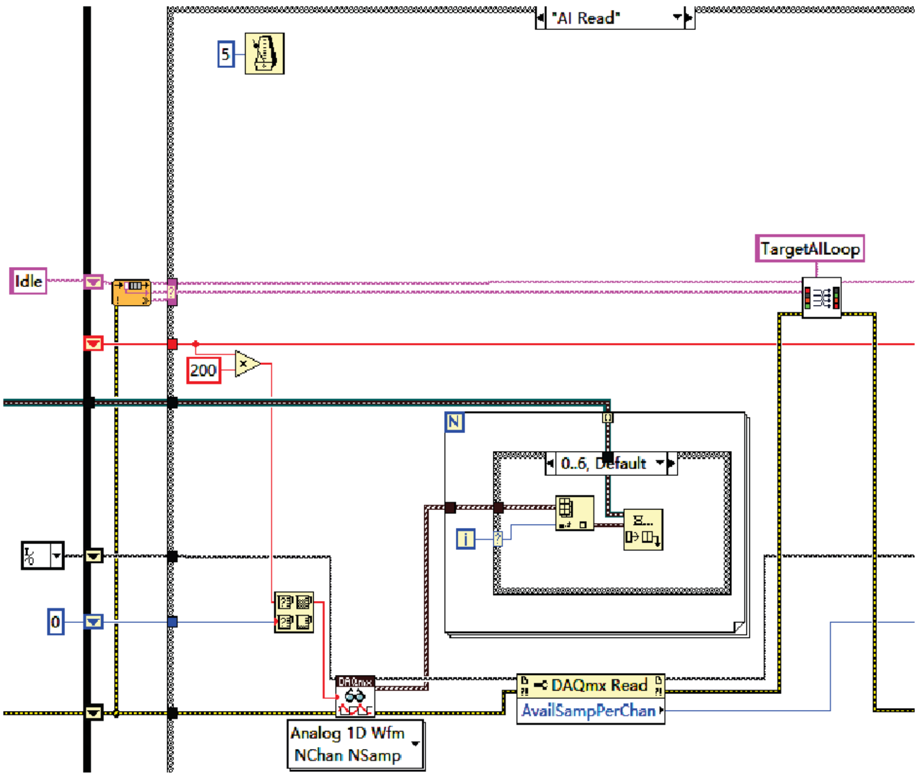

Figure 5 AI data acquisition program.

3.4 Calculation Method of Electrical Equipment Parameters

3.4.1 Reactive Power Compensation and Phase and Voltage Regulation Calculation

Considering that there is no power loss when the main transformer is fully loaded, it needs to be configured according to 10%–30% of the main transformer capacity, that is, a single 20MVA transformer needs to be equipped with 2-6Mvar capacitive reactive power compensation equipment. Therefore, in order to take into account the reactive power loss of the main transformer and to meet the needs of the reactive power balance on the load side, it is recommended to install a new equipment compensation device for the certain transformer in this period. This new equipment is a 20MVA main transformer with 2 × 2Mvar capacitive, and the final device will be configured for each main transformer with a 2 × 2Mvar capacitive reactive power compensation device. In order to cooperate with the calculation results of the reactive power compensation and high-voltage side tap adjustment phase and voltage regulation, in each operation mode of the calculation, an on-load voltage regulation transformer is adopted. The 66kV busbar voltage variation range of a 66kV substation is (61.6 ∼ 64.5) kV, which are all consistent with procedure requirements. Table 3 shows the calculation results of phase modulation and voltage regulation.

3.4.2 Short Circuit Current Calculation

The calculation of the short-circuit current mainly includes the calculation of standard values for transformers, reactors, circuits, etc.

Capacity standard value:

$$S^* = \frac{S}{S_j} \tag{1}$$

Voltage standard value:

$$U* = \frac{U}{U_j} \tag{2}$$

Standard current value:

$$I^* = \frac{I}{I_j} = \frac{I \times \sqrt{3} \times U_j}{S_j} \tag{3}$$

Rated standard value of capacity:

$$S^* = \frac{S}{S_N} \tag{4}$$

Rated standard value of reactance:

$$X^* = \frac{X}{X_N} = \frac{X \times S_N}{U_N^2} \tag{5}$$

Rated standard value of current:

$$I^* = \frac{I}{I_N} = \frac{I \times \sqrt{3} \times U_N}{S_N} \tag{6}$$

The calculation results are shown in Table 4.

3.4.3 Capacitive Current Calculation

(1) 66kV side: Based on the operation mode of the power grid in the region, 66kV arc suppression coil compensation equipment is scattered in various 66kV substations.

Table 3 Bus voltage variation range of a 66kV substation.

	Project	66kV side tap (kV)	66kV Bus voltage 10kV	10kV Bus voltage	10kV reactive power compensation (Mvar)
2018	Summer way	$66 \times (1 - 3 \times 1.25\%)$	61.6	103	2（容性）
	Summer small way	$66 \times (1 - 3 \times 1.25\%)$	63.4	10.5	0
	Winter University Way	$66 \times (1 - 3 \times 1.25\%)$	633	10.5	0
	Winter small way	$66 \times (-3 \times 1.25\%)$	64.5	10.7	0

Table 4 Short-circuit current calculation results.

Busbar	Three-phase short-circuit current (kA)	Single phase short circuit current (kA)
66kV bus in Batay 66kV substation	3.1	3.5
66kV bus in Wujiahu 66kV substation	5.3	5.7
66kV bus in Hurix 66kV substation	2.5	3.0

It is now calculated that the total length of the 66kV line in the system is 521.8 kilometers, the existing overhead single-circuit line is about 10.8 kilometers, and the arc suppression coil compensation capacity is 7600kVA. The single-phase grounding capacitance current of 66kV overhead line is as follows:

$$Ic1 = (3.3 \times Ue \times l \times 10^{-3})(A) \quad (7)$$

(2) Post-processing of the calculation results recommends an increase in the capacitance current by 10% on the basis of the original capacitance current.

$$Ic = 3.3 \times 66 \times (521.8 + 10.8) \times 112\% \times 10^{-3} = 129.9(A) \quad (8)$$

(3) Selection of arc suppression coil capacity:

$$S = 1.35Ic \times U/\sqrt{3} = 1.35 \times 129.9 \times 66 \div 1.732 = 6682.5kVA \quad (9)$$

The capacity of the existing arc suppression coil is 7600kVA, and the required capacity is 6682.5kVA, that is, the capacity of the arc suppression coil is greater than the required capacity, so it is not necessary to install the arc suppression coil on the 66kV side at this time

(4) Selection of the capacity of 10kV arc suppression coil A 66kV substation is planned with 12 10kV outgoing lines, and 8 substations are planned to be constructed in this phase. All overhead outgoing lines are considered, and the overhead line length of each circuit is calculated to be 15km. The capacitance current of 10kV overhead line is then calculated with the following equation:

$$Ic1 = 0.025 \times L = 0.025 \times 15 \times 12 = 4.5(A) \quad (10)$$

When all the steps are completed, the final current obtained is 4.5A, and the national standard stipulates that arc suppression coils only need to be installed when the capacitor current exceeds 10A. Therefore, according to national regulations, arc suppression coils are not required in this phase of the project.

3.5 Electrical Equipment Parameter Collection Results and Analysis

66kV substation planning design and connection system research 2.5.2+2.5.3 (38/68) to (40/68) Table 2–16+ Table 2–1766kV adopts outdoor AIS equipment. Through the analysis of the following table, we can draw the conclusion that according to the safest short-circuit current level specified by the national standard, the device will short-circuit when the current of the device reaches 32KA.

Through the analysis of the parameter table, it can be determined that the normal working voltage is 10KV, the circuit in the device will short-circuit when the current of the device reaches 32KA, and the maximum current that the circuit in the device can withstand is 80KA, when the current exceeds 80KA, most of the lines will be burned. When it is necessary to configure shunt capacitors for the handcart switchgear, it must be ensured that the working voltage of the shunt capacitor is also 10KV, and the shunt capacitor can only be arranged outside the handcart switchgear. Table 6 shows the main equipment selection of 10kV.

4. CONCLUSION

This article is based on the electrical equipment parameter collection system of Wi-Fi technology. The realization of Wi-Fi communication is because the ESP8266 wireless module integrated with the IEEE 802.11 protocol is used to form a wireless sensor network with the Access Point as the core. The new type of wireless sensor network solves the traditional wireless sensor network's short transmission distance and small coverage area, enabling long-distance information transmission and data synchronization to be realized. Not only that, the data processing capability of each node in the new wireless sensor network is stronger, and the information transfer rate between nodes is higher [14]. When researching the new wireless network, this paper studies three different types of wireless sensor networks based on gateway nodes, routing nodes and network terminal nodes [15]. In addition, this paper also analyzes the different

Table 5 Main equipment parameters of 66kV.

Equipment name	Type and main parameters	Number of current period
Tank circuit breaker	Rated voltage: 72.5kV, rated current: 2000A, rated breaking current: 31.5kA, rated short-circuit withstand current: 31.5kA, three-phase mechanical linkage, spring control mechanism, built-in current transformer, rated current ratio 2X400/5A, accuracy level combination: 5P20/5P20/0.2S/0.2S 30/30 /30/30	3 sets
Isolation switch	Outdoor three-phase, double column, horizontal rotating type, rated current: 2000A; thermally stable Constant current 31.5kA, main knife and ground knife are electric operating mechanism, double grounding	5 groups
	Outdoor three-phase, double column, horizontal rotating type, rated current: 2000A; thermally stable Constant current 31.5kA, main knife and ground knife are electric operating mechanism, single grounding	5 groups
Voltage transformer	TYD-66/$\sqrt{3}-0.02$H, $(66/\sqrt{3})/(0.1/\sqrt{3})/(0.1/\sqrt{3})/(0.1/3)$kV, $0.2/0.5/3$P	6 sets
	TYD-66/$\sqrt{3}-0.01$H, 0.5/3P$\frac{110}{\sqrt{3}}$, $\frac{0.1}{\sqrt{3}}/0.1$kV	2 sets
Lightning arrester	Zinc oxide, 96/250W, 5kA, with online monitor	6 sets
Neutral point arrester	Zinc oxide, 60/144W, 5kA, with online monitor	1 set

Table 6 10kV main equipment parameter table.

Serial number	Equipment name		Type and main parameters	Remarks
1	10kV outdoor shunt capacitor complete set		Single group capacity 2000kvar Parallel capacitor, single capacity 334, with grid. Discharge coil: FDE-11/ -l-lW Zinc oxide arrester, 17/46 Four pole isolation switch, 1250A Series reactor, reactance rate 5%	2 sets
2	Switchgear	Vacuum circuit breaker	12kV, 3150A, 31.5kA 12kV, 1250A, 31.5kA	Main transformer Outgoing, reactive
		Earthing switch	12kV, 25kA/4s	
		Current Transformer	Dry, l0kV, 3000/5A, 5P30/5P30/0.2S/0.2S Dry, l0kV, 300–600/5A, 5P30/0.5/0.2S	Main transformer Outgoing, reactive
		Voltage transformer	$\frac{10}{\sqrt{3}}/\frac{0.1}{\sqrt{3}}/\frac{0.1}{\sqrt{3}}/\frac{0.1}{\sqrt{3}}$kV	Busbar equipment
		Dry station change	Dry, capacity l00kVA, $10.5\pm2\times2.5\%$/0.4kV, D,yn1 1 UK $=4\%$	
		Fuse	10kV, 0.5A, 25kA	
		Lightning arrester	YH5WZ-17/45	
		Main bus	2X(TMY-100X10)	

circuits in the process of information transmission and data synchronization. Both the transmission and processing capabilities of the hardware and software, and corresponding suggestions on how to improve the information transmission and processing capabilities of these circuits and programs, so that the efficiency of information transmission and data synchronization of the new wireless sensor network has been greatly improved [16]. The software, written in the Microsoft Visual Studio 2005 environment, uses a socket configuration to realize the functions of display, processing and storage of data in the sensor network, which are monitored by the control computer. By layering the serial port protocol, the workload of CAN's online data collection is reduced considerably, which undoubtedly improves the performance and scalability of the device. This is useful for communication between the communication protocols when the data type is fixed.

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